1. PUBLIC HEALTH STATEMENT

This public health statement tells you about strontium and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. Strontium has been found in at least 101 of the 1,585 current or former NPL sites. However, the total number of NPL sites evaluated for strontium is not known. As more sites are evaluated, the sites at which strontium is found may increase. This information is important because exposure to strontium may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to strontium, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS STRONTIUM?

Strontium is a natural and commonly occurring element. Strontium can exist in two oxidation states: 0 and +2. Under normal environmental conditions, only the +2 oxidation state is stable enough to be important. Pure strontium is a hard, white-colored metal, but this form is not found in the environment. Rather, strontium is usually found in nature in the form of minerals. Strontium can form a variety of compounds. Strontium compounds do not have any particular smell. There are two types of strontium compounds, those that dissolve in water and those that do not. Natural strontium is not radioactive and exists in four stable types (or isotopes), each of which can be written as ^{84}Sr, ^{86}Sr, ^{87}Sr, and ^{88}Sr, and read as strontium eighty-four, strontium eighty-six, etc. All four isotopes behave the same chemically, so any combination of the four would have the same chemical effect on your body.

Rocks, soil, dust, coal, oil, surface and underground water, air, plants, and animals all contain varying amounts of strontium. Typical concentrations in most materials are a few parts per million (ppm). This corresponds to about 4 tons of strontium in 1 square mile of soil that is 1 foot deep, or about half a teaspoon of strontium in a typical 8-cubic yard dump truck load of soil. In metric terms, a part per million is equivalent to one microgram (μg=10^{-}6 g) per gram (g) or one milligram (mg=10^{-}2 g) per kilogram (kg=10^{2} g). Some rocks and soils may contain greater amounts of strontium. If the amount is great enough, (e.g., strontium content >90%), the strontium may be present in commercial quantities to be mined as an ore.

Strontium ore is found in nature as the minerals celestite and strontianite. High grade celestite ore is imported from Mexico into the United States. After the strontium is extracted from strontium ore, it is concentrated into strontium carbonate or other chemical forms by a series of chemical processes. Strontium compounds, such as strontium carbonate, are used in making ceramics and glass products, pyrotechnics, paint pigments, fluorescent lights, medicines, and other products. For more information, see Chapter 5.

Radioactive Strontium. Strontium can also exist as radioactive isotopes (see Chapter 3). ^{90}Sr, or strontium ninety, is the most dangerous of the radioactive isotopes. ^{90}Sr is formed in nuclear reactors or during the explosion of nuclear weapons. Radioactive isotopes of strontium are not stable, and are constantly changing into new isotopes or elements by giving off radiation. The radioactive half-life is the time that it takes for half of a radioactive strontium isotope to give off its radiation and change into a different element. ^{90}Sr has a half-life of 29 years. ^{90}Sr changes into another element and gives off radiation. ^{90}Sr transforms into ^{90}Y (or yttrium ninety) and gives off a particle called a beta particle or beta radiation. ^{90}Sr is called the parent, and ^{90}Y is called the transformation product or daughter. When the transformation product is radioactive, it keeps transforming until a stable product is formed. ^{90}Y transforms into a stable ^{90}Zr (or zirconium ninety) product. During these decay processes, the parent ^{90}Sr and its decay products each release radiation. For more information on radiation, see Appendix D and the glossary, Chapter 10, at the end of this profile or the *ATSDR Toxicological Profile for Ionizing Radiation*.

^{90}Sr has limited use and is considered a waste product. Radioactive strontium can form a variety of compounds, which do not have any particular smell. There are two types of radioactive strontium compounds, those that dissolve in water and those that do not. For more information about the properties and use of radioactive strontium, see Chapters 4 and 5.

1.2 WHAT HAPPENS TO STRONTIUM WHEN IT ENTERS THE ENVIRONMENT?

Stable Strontium. Strontium is a naturally occurring element and is present to some degree in almost everything in the environment, including soil, rocks, water, and air. Each strontium compound dissolves to its own special extent in water, ranging from not soluble to very soluble. This helps determine how easily the compound can move through the environment.

In air, strontium compounds are present mostly as dust. Emissions from burning coal and oil increase strontium levels in air. The amount of strontium that has been measured in air in different parts of the United States by the EPA ranges from not detected to 20 trillionths of a gram (g) per cubic meter (m^3). Very small dust particles of strontium in the air fall out of the air onto surface water, plant surfaces, and soil either by themselves or when rain or snow falls. These particles of strontium eventually end up back in the soil or in the bottoms of lakes, rivers, and ponds, where they stay and mix with strontium that is already there.

Most of the strontium in water is dissolved. Strontium in water comes from different sources. Most of it comes from dissolving strontium out of rocks and soil that water runs over and through. Only a very small part is from the settling of strontium dust out of the air. Some strontium is suspended in water, as in muddy water. The amount of strontium that has been measured in drinking water in different parts of the United States by the EPA is generally less than 1 millionth of a gram (i.e., 1 microgram or μg) for every liter (L) of water, respectively. EPA has found that the levels of strontium in water in different parts of the United States are low in most cases, and that water containing strontium is safe to drink.

Strontium is found naturally in soil in amounts that vary over a wide range, but the typical concentration is 2 ten-thousandths of a gram per kilogram (kg) of soil (or 0.2 ppm). This corresponds to about a teaspoon of strontium in a typical 8-cubic yard dump truck load of soil. Most of the manufactured strontium that enters waterways comes when industry dumps waste water and when strontium dust in the air from industrial activities settles over water. The disposal of coal ash, incinerator ash, and industrial wastes may increase the concentration of strontium in soil. A major portion of strontium in soil does dissolve in water, so it is likely to move deeper into the ground and enter groundwater. However, strontium compounds may stay in the soil for years without moving downward into groundwater. In the environment, chemical reactions can change the water-soluble strontium compounds into insoluble forms. In some cases, water-insoluble strontium compounds can change to soluble forms. Exposure to water-soluble strontium compounds in the environment will pose a greater threat to human health than exposure to water-insoluble forms. For more information about the transport properties of strontium in the environment, see Chapter 6.

Radioactive Strontium. ^{90}Sr is not a naturally occurring substance; its presence in the environment is a result of human activities, such as the prior testing of nuclear bombs in the air and leaks from radioactive storage and waste sites. Radioactive decay is the only way for decreasing the concentration of ^{90}Sr. Eventually, all ^{90}Sr will be converted to stable zirconium.

The amount of ^{90}Sr in dust is very small, and it is only a very small fraction of the total concentration of strontium (both radioactive and stable) in air. Very small dust particles of ^{90}Sr in the air fall out of the air onto surface water, plant surfaces, and soil either by themselves or when rain or snow falls. These particles of ^{90}Sr eventually end up back in the soil or in the bottoms of lakes, rivers, and ponds, where they stay and mix with strontium (both radioactive and stable) that is already there.

Most of the ^{90}Sr in water is dissolved. ^{90}Sr in water comes from the settling of ^{90}Sr dust out of the air. Some ^{90}Sr is suspended in water, as in muddy water. The amount of ^{90}Sr that has been measured in drinking water in different parts of the United States by EPA is generally less than one tenth of a trillionth of a Ci (0.1 pCi or ~0.37 Bq) for every L of water, respectively. EPA has found that the levels of ^{90}Sr in water in different parts of the United States are low in most cases, and that water containing ^{90}Sr is safe to drink.

The amount of ^{90}Sr in soil is very small and is only a fraction of the total concentration of strontium in soil. High concentrations of ^{90}Sr in soil may be found near hazardous waste sites, radioactive waste sites, and Department of Energy facilities located around the United States. A major portion of radioactive strontium in soil does dissolve in water, so it is likely to move deeper into the ground and enter groundwater. However, ^{90}Sr compounds may stay in the soil for years without moving downward into groundwater. In the environment, chemical reactions can change the water-soluble radioactive strontium compounds into insoluble forms. In some cases, water-insoluble radioactive strontium compounds can change to soluble forms. Exposure to water-soluble radioactive strontium compounds in the environment will pose a greater threat to human health than exposure to water-insoluble forms. For example, water-soluble forms may contaminate drinking water. For more information about the transport properties of radioactive strontium in the environment, see Chapter 6.

1.3 HOW MIGHT I BE EXPOSED TO STRONTIUM?

Stable Strontium. Strontium is found nearly everywhere in small amounts, and you can be exposed to low levels of strontium by breathing air, eating food, drinking water, or accidentally eating soil or dust that contains strontium. Food and drinking water are the largest sources of exposure to strontium. In the United States, the average concentration of strontium in air is 20 nanograms (ng) (1 ng=1 billionth of a gram) in 1 m^3 of air. In U.S. cities, the average air concentration is higher because strontium is released from burning coal and fuel oil. Strontium was found in 99% of 1,836 water samples obtained throughout the United States. Of these samples, the average strontium concentration was 424 milligrams (mg) (1 mg=1 thousandth of a gram) in 1 L of water. Because of the nature of strontium, some of it gets into fish, vegetables, and livestock. Grain, leafy vegetables, and dairy products contribute the greatest percentage of dietary strontium to humans. The concentration of strontium in leafy vegetables, such as cabbage, grown in the United States is less than 64 mg in a kg of the fresh vegetables (i.e., 64 ppm). For most people, the intake of strontium will be moderate. More information about strontium exposure can be found in Chapter 6.

Radioactive Strontium. ^{90}Sr is found nearly everywhere in small amounts from past nuclear accidents and fallout from nuclear explosions. You can be exposed to low levels of ^{90}Sr by eating food, drinking water, or accidentally eating soil or dust that contains ^{90}Sr. Food and drinking water are the largest sources of exposure to ^{90}Sr. In the United States, the average concentration of ^{90}Sr in surface water and groundwater is 1.9 picocuries and 0.5 picocuries (pCi; where 1 pCi=1 trillionth of a curie) in 1 L of water, respectively. Because of the nature of ^{90}Sr, some of it gets into fish, vegetables, and livestock. Grain, leafy vegetables, and dairy products contribute the greatest percentage of dietary ^{90}Sr to humans. The concentration of ^{90}Sr in fresh vegetables grown in the United States is less than 9 pCi in 1 kg of dried vegetables (in a hot oven). The intake of radioactive strontium for most people will be small. You can take in more ^{90}Sr if you eat food that was grown on a radioactive strontium-contaminated hazardous waste site. More information about radioactive strontium exposure can be found in Chapter 6.

1.4 HOW CAN STRONTIUM ENTER AND LEAVE MY BODY?

Both stable strontium and radioactive strontium enter and leave the body in the same way.

If a person breathes in vapors or dust containing a strontium chemical that is soluble in water, then the chemical will dissolve in the moist surface inside the lungs and strontium will enter the bloodstream relatively quickly. If the strontium chemical does not dissolve in water easily, particles may rest inside of the lung for a time. When you eat food or drink water that contains strontium, only a small portion leaves the intestines and enters the bloodstream. In young people, a larger portion enters the bloodstream than in adults. If a fluid mixture of a strontium chemical is placed on the skin, the strontium will pass through the skin very slowly and then enter the bloodstream. If the skin has scratches or cuts, strontium will pass through the skin much more quickly.

Once strontium enters the bloodstream, it is distributed throughout the body, where it can enter and leave cells quite easily. In the body, strontium behaves very much like calcium. A large portion of the strontium will accumulate in bone. In adults, strontium mostly attaches to the surfaces of bones. In children, whose bones are still growing, strontium may be used by the body to create the hard bone mineral itself. As a result the strontium will be stored all through the bone for a long time (years). Because of the way bone grows, with continual remodeling, strontium will be locally dissolved from bone and recirculate through the bloodstream, where it may be reused by growing bone, or be eliminated. This process accounts for the slow elimination of strontium over time.

Strontium is eliminated from the body through urine, feces, and sweat. Elimination through urine and a very small amount through sweat occurs as blood passes through the kidneys or the skin. Elimination through urine may occur over long periods, when small amounts of strontium are released from bone and do not get recaptured by bone. When strontium is taken in by mouth, the portion that does not pass through the intestinal wall to enter the bloodstream is eliminated through feces during the first day or so after exposure.

See Chapter 3 for further information.

1.5 HOW CAN STRONTIUM AFFECT MY HEALTH?

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body. In the case of a radioactive chemical, it is also important to gather information concerning the radiation dose and dose rate to the body. For some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

Stable Strontium. The only stable strontium chemical that is considered to be very harmful in small quantities is strontium chromate, but this is because of toxic chromium. Workers who breathed air contaminated with strontium chromate had a higher rate of lung cancer, but this problem has been reduced by safety procedures (e.g., breathing masks) adopted by manufacturers. One person was reported to have an allergic reaction after breathing smoke from an emergency flare that contained strontium, as well as other irritating chemicals, but this effect has not been reported elsewhere. From normal breathing, eating, and drinking, adults take in about 3.2 mg of stable strontium per day from the environment. Exposures can be considerably higher without causing harm. (See Section 1.9 for recommended exposure levels.) Eating or drinking stable strontium at levels that are much higher than the recommended levels, especially if dietary calcium is low, may cause problems with bone growth in children. This is discussed in Section 1.6. Ordinary strontium salts are not harmful to the skin.

Animal studies showed that eating or drinking very large amounts of stable strontium can be lethal. In these cases, the amount of strontium was one-third or more of the dietary requirement for calcium, a mineral that is needed in the thousands of ppm range. Consequently, the public is not likely to encounter such high levels of strontium. In these unusually high amounts, the process of bone development was disrupted, as strontium replaced calcium, the usual building-block of bone mineral. Strontium had more severe effects on bone growth in young animals than in adults.

It is not known whether stable strontium affects reproduction in people, but stable strontium chloride does not appear to be toxic to human spermatozoa. The effect of stable strontium on reproduction in animals is not known. The Department of Health and Human Services has determined that strontium chromate may reasonably be anticipated to be a carcinogen, but this is because of chromium. No other form of stable strontium has been shown to cause cancer in humans or animals.

Radioactive Strontium. The harmful effects of radioactive strontium are caused by the physical effects of radiation and the bone-seeking behavior of strontium. Injection of radioactive strontium (^{89}Sr), which is used medically for treating bone pain for cancers that have spread to the bone, may reduce blood cell counts. This also occurs in animals exposed by lung or by mouth to radioactive strontium. Radioactive strontium taken up into bone, where it will be retained for a long time, will release particles of energy that damage the tissues nearby. The body has a natural mechanism to repair such damage (which is why exposure to low levels of radiation is not harmful), but in the case of a high exposure to radioactive strontium, the natural repair mechanism may not be able to keep up. At very high exposures, radiation from radioactive strontium in bone damages the bone marrow, which is the major source of blood cells in the body. Numerous problems occur when the number of blood cells is reduced. A loss of red blood cells, anemia, prevents the body from getting sufficient oxygen, so that fatigue may occur. A loss of platelets may prevent the blood from clotting properly, and may result in abnormal bleeding, especially in the digestive tract. A loss in white blood cells harms the body's ability to fight infectious disease.

Radiation damage may also occur from exposure to the skin. Medically, radioactive strontium probes have been used intentionally to destroy unwanted tissue on the surface of the eye or skin. The eye tissues sometimes become inflamed or abnormally thin after a long time. Thinning of the lower layer of the skin (dermis) has also been reported in animal studies as a delayed effect. In addition, skin and bone cancer were reported in animals that were irradiated on the skin by exposure to a radioactive strontium probe.

It is not known whether exposure to radioactive strontium would affect human reproduction. Harmful effects on animal reproduction occurred at high doses.

Radioactive strontium may cause cancer as a result of damage to the genetic material in cells. An increase in leukemia over time has been reported in one foreign population that was exposed during 1949–1956 to relatively large amounts of ^{90}Sr (and other radioactive materials) that were accidently released from a nuclear weapons plant. Cancers of the bone, nose, and lung (in the case of a breathing exposure), and leukemia have been reported in animal studies. In addition, skin and bone cancer were reported in animals that were irradiated on the skin by exposure to a radioactive strontium probe. The International Agency for Research on Cancer (IARC) has determined that radioactive strontium is carcinogenic to humans, because it is deposited inside the body and emits beta radiation. The EPA has determined that radioactive strontium is a human carcinogen.

To learn more about the health effects of exposure to stable or radioactive strontium, see Chapter 3.

1.6 HOW CAN STRONTIUM AFFECT CHILDREN?

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans.

Stable Strontium. Children, like adults, are exposed to small amounts of stable strontium in drinking water and in food, since crops take up strontium from the soil. Young children who have more hand-to-mouth activity or who eat soil may accidently eat more strontium. As long as a child has a healthy diet with enough protein, calcium, and vitamin D, these exposures are not likely to be harmful. Since milk sold in the United States is generally fortified with vitamin D, children in this country are protected to some degree against strontium toxicity. (See Section 1.9 for governmental recommendations for levels of exposure to strontium.) One study of a farming district in Turkey showed that where the amounts of strontium in the soil were high, a higher percentage of children had 'rickets', a disease resulting in abnormal bone joints, knock-knees, or bow-legs. The diet of these children consisted mostly of grain products grown in the strontium-rich soil, with little animal protein and calcium; the available milk was unlikely to have been fortified with vitamin D. Thus, the ratio of strontium intake to calcium intake was probably abnormally high in these children.

Many studies have shown that young animals are more vulnerable than adults when stable strontium is eaten because a higher percentage is taken up by the intestinal wall, passed to the bloodstream, and taken up by growing bones. Excess strontium is more harmful when the diet does not have enough calcium because it substitutes for calcium imperfectly in the growing bone and also interferes with normal calcium uptake. In general, strontium will remain longer in the bodies of children, compared to adults, since bone growth occurs more rapidly than in adults where bone breakdown (resorption) is accelerated. Thus, in adults, strontium attaches mostly to the surface of bone and is removed in a short time.

During pregnancy and lactation, some of the calcium stored in the bones of the mother is released and transferred to the fetus through the placenta or to an infant through breast milk. If the mother's bones contain strontium from previous exposure, a similar release and transfer may occur. If a mother is newly exposed to strontium, some will be transferred to the fetus, although the percentage of transfer is likely to be low.

Radioactive Strontium. The human body absorbs, distributes, and gets rid of radioactive strontium in the same ways as stable strontium. Children are likely to be more vulnerable than adults to the effects of radioactive strontium because of the higher rate of uptake and binding into growing bone, as described in the previous section. In general, radioactive strontium is not found in amounts high enough to cause rickets in children. However, it is potentially harmful to children because of the possibility of high energy radiation damage to bone and bone marrow, leading to the possibility of anemia or cancer (from damage to DNA). Children are potentially more vulnerable than adults because they retain strontium (stable or radioactive) in bone for a longer time.

The beta particles released from ^{90}Sr only travel short distances through tissue. For that reason, the fetus is not likely to be irradiated by uterine tissue of the mother. However, radioactive strontium, like stable strontium, may be transferred to the fetus across the placenta. Infants may be exposed to radioactive strontium by drinking the breast milk of exposed mothers. Although the possible effect of radioactive strontium on children was a major concern during the period of above-ground atomic weapons testing, no increase in cancer rates because of fallout exposure was identified. Apparently, the environmental levels have been low enough that the body's natural repair mechanisms can handle the rate of genetic damage that may occur. However, an increase in leukemia has been detected in one population that was exposed to unusually high levels of radiostrontium because of accidental releases from a nuclear weapons facility some decades ago. Animal studies have demonstrated that high levels of radioactive strontium will cause more damage and higher cancer rates in young animals compared to adults.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO STRONTIUM?

If your doctor finds that you have been exposed to significant amounts of strontium, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

It is possible that higher-than-normal levels of stable strontium may occur naturally in soil in some places or that higher levels of radioactive strontium may be found in soil near hazardous waste sites. Some children eat a lot of dirt. You should prevent your children from eating dirt. Make sure they wash their hands frequently, and before eating. If you live near a hazardous waste site, discourage your children from putting their hands in their mouths or from engaging in other hand-to-mouth activities.

Stable Strontium. Since strontium is so common in the environment, and is naturally present in food and water, we cannot avoid being exposed to it. For several reasons, having a balanced diet with sufficient vitamin D, calcium, and protein will be protective by reducing the amount of ingested strontium that is absorbed. Milk sold in the United States is fortified with vitamin D and is also an important source of calcium and protein. Although the body absorbs strontium by mechanisms similar to those of calcium, there is a preference for calcium. Vitamin D helps maintain the ability of the intestine to take up calcium. Animal studies have shown that with diets lacking protein, the amount of strontium that is absorbed increases.

Radioactive Strontium. The advice given for stable strontium applies to radioactive strontium. It is also important for families to follow the advice of public health officials who will publish guidelines for reducing exposure to radioactive strontium when necessary.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO STRONTIUM?

Stable Strontium. All people have small amounts of stable strontium in their bodies, mostly in bone. It can be measured in the blood, hair, feces, or urine. The amount is usually measured by its mass (grams). Measurements in urine can show whether you have been exposed recently to larger-than-normal amounts of strontium. Measurements in hair can reveal whether you were exposed to high amounts of strontium in the past. Most physicians do not test for strontium in their offices, but can collect samples and send them to a special laboratory. Normal x-ray procedures can show changes in bone that may occur from exposure to high amounts of strontium. However, these changes may have other causes (vitamin D deficiency or exposure to an excess of some other trace metal) and the x-ray cannot determine that strontium is involved.

Radioactive Strontium. If a person has been exposed to radioactive strontium, special tests can be used to measure radioactive strontium in blood, feces, or urine. These tests are most useful when done soon after exposure, since radioactive strontium is quickly incorporated into bone and its release from bone occurs in very small amounts over a period of years. Radioactive strontium can be measured by its mass (in grams) or by its radiation emissions. These emissions, which differ for the various isotopes of strontium, are used to tell the amount of radioactive strontium (in Curies or Bequerels) and the radiation dose in gives to your body (in Sieverts or rem). In a procedure that is similar to being x-rayed, specialized equipment can measure radioactive strontium that has attached to bone.

For more information, please read Chapters 3 and 7.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations <u>can</u> be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and

Health Administration (OSHA),the Food and Drug Administration (FDA) and the Nuclear Regulatory Commission (NRC).

Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR), the National Institute for Occupational Safety and Health (NIOSH), and the FDA.

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals; then they are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for strontium include the following:

Stable Strontium. There are few federal guidelines for stable strontium. The EPA has established a reference dose (RfD) for stable strontium. This is the amount that could be taken by mouth daily for life without causing harmful health effects in adults or children. The RfD for stable strontium is 0.6 mg strontium/kg of body weight/day. This means that for a person weighing about 155 pounds (70 kg), intakes of approximately 40 mg of strontium should be tolerated without ill effect. This amount is about 5% of the daily calcium requirement.

The RfD would not apply to strontium in strontium chromate because of the harmful effects of chromate. The American Conference of Governmental Industrial Hygienists suspects strontium chromate to be a cancer-causing substance and has recommended that workers not be exposed to amounts in air higher than 0.0005 mg/m^3 on average over an 8-hour period (8-hour time-weighted-average or TWA). Under the Clean Water Act, strontium chromate is listed as a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substance, and amounts greater than 10 pounds released into the environment must be reported.

Radioactive Strontium. The Department of Energy (DOE) has established derived air concentrations (DAC) for workplace exposure to radiation at DOE facilities. The DAC ranges from 0.000000002 μCi/mL (2×10^{-9} μCi/mL of air) for 100-day retention in the lung to 0.000000008 μCi/mL (8×10^{-9} μCi/mL of air) for retention less than 10 days. The Nuclear Regulatory Commission established an annual intake limit of 20 μCi for on-the-job exposure to ^{90}Sr in air.

The EPA set standards for the concentration of ^{90}Sr in community water supplies. Water supplies are measured about four times a year, and the average annual concentration of ^{90}Sr should not exceed 8 pCi/L. This very conservative standard is much lower than the level at which even subtle effects from radiation have been detected.

Health advisories were established by the EPA for exposure levels in water. The limit for a 22-pound (10-kilogram) child is 25 mg/L no matter how long or how often the exposure occurs (once, 10 days, or longer period). For a 155-pound (70-kilogram) adult, the long-term (more than 10 days) and drinking water equivalent levels (DWEL) are 90 mg/L and the lifetime level is 17 mg/L. These levels are expected to protect against harmful effects of ^{90}Sr. The Nuclear Regulatory Commission set a workplace value of 31 μCi for the amount of ^{90}Sr that can be taken in by mouth on a yearly basis without any harmful effects.

More information on regulations and guidelines is available in Chapter 8.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department, your regional Nuclear Regulatory Commission office, or

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, GA 30333

* <u>Information line and technical assistance</u>

Phone: 1-888-42-ATSDR (1-888-422-8737)
Fax: (404) 498-0057

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

* <u>To order toxicological profiles, contact</u>

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 1-800-553-6847 or (703) 605-6000